Government of South Australia

SACE Board of SA

External Examination 2009

2009 CHEMISTRY

ATTACH SACE REGISTRATION NUMBER LABEL TO THIS BOX

QUESTION BOOKLET

1

17 pages, 4 questions

Wednesday 11 November: 1.30 p.m.

Time: 3 hours

Question Booklet 1

Examination material: Question Booklet 1 (17 pages)
Question Booklet 2 (15 pages)
Question Booklet 3 (11 pages)
one SACE registration number label

Approved dictionaries and calculators may be used.

Instructions to Students

1. You will have 10 minutes to read the paper. You must not write in your question booklets or use a calculator during this reading time but you may make notes on the scribbling paper provided.

2. You will be expected to extract information such as atomic number and relative atomic mass from the periodic table on page 3 of Question Booklet 1, which you may remove from this booklet before the examination begins. Tables showing the relative activities of metals and SI prefixes are on the back of page 3.

3. This paper consists of twelve questions, four in Question Booklet 1, four in Question Booklet 2, and four in Question Booklet 3:

   Question Booklet 1 (Questions 1 to 4)
   Answer ***all parts*** of Questions 1 to 4 in the spaces provided in this question booklet.
   You may write on page 17 if you need more space to finish your answers.

   Question Booklet 2 (Questions 5 to 8)
   Answer ***all parts*** of Questions 5 to 8 in the spaces provided in Question Booklet 2.
   You may write on page 15 of Question Booklet 2 if you need more space to finish your answers.

   Question Booklet 3 (Questions 9 to 12)
   Answer ***all parts*** of Questions 9 to 12 in the spaces provided in Question Booklet 3.
   You may write on page 11 of Question Booklet 3 if you need more space to finish your answers.

4. There is no need to fill all the space provided; clearly written, well-expressed answers are required. If you delete part or all of an answer you should clearly indicate your final answer.

5. The total mark is 200. The twelve questions are of approximately equal value.

6. Attach your SACE registration number label to the box at the top of this page. Copy the information from your SACE registration number label into the boxes on the front covers of Question Booklet 2 and Question Booklet 3.

7. At the end of the examination, place Question Booklet 2 and Question Booklet 3 inside the back cover of Question Booklet 1.

STUDENT'S DECLARATION ON THE USE OF CALCULATORS

By signing the examination attendance roll I declare that:

- my calculators have been cleared of all memory;
- no external storage media are in use on these calculators.

I understand that if I do not comply with the above conditions for the use of calculators I will:

- be in breach of the rules;
- have my marks for the examination cancelled or amended;
- be liable to such further penalty, whether by exclusion from future examinations or otherwise, as the SACE Board of South Australia determines.

You may remove this page from the booklet by tearing along the perforations.

PERIODIC TABLE OF THE ELEMENTS

1 **H** Hydrogen 1.008																	2 **He** Helium 4.003
3 **Li** Lithium 6.941	4 **Be** Beryllium 9.012											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31											13 **Al** Aluminium 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.06	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.90	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.70	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.38	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.59	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (97)	44 **Ru** Ruthenium 101.1	45 **Rh** Rhodium 102.9	46 **Pd** Palladium 106.4	47 **Ag** Silver 107.9	48 **Cd** Cadmium 112.4	49 **In** Indium 114.8	50 **Sn** Tin 118.7	51 **Sb** Antimony 121.8	52 **Te** Tellurium 127.6	53 **I** Iodine 126.9	54 **Xe** Xenon 131.3
55 **Cs** Caesium 132.9	56 **Ba** Barium 137.3	57[1] **La** Lanthanum 138.9	72 **Hf** Hafnium 178.5	73 **Ta** Tantalum 180.9	74 **W** Tungsten 183.8	75 **Re** Rhenium 186.2	76 **Os** Osmium 190.2	77 **Ir** Iridium 192.2	78 **Pt** Platinum 195.1	79 **Au** Gold 197.0	80 **Hg** Mercury 200.6	81 **Tl** Thallium 204.4	82 **Pb** Lead 207.2	83 **Bi** Bismuth 209.0	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
87 **Fr** Francium (223)	88 **Ra** Radium (226)	89[2] **Ac** Actinium (227)	104 **Rf** Rutherfordium (267)	105 **Db** Dubnium (268)	106 **Sg** Seaborgium (271)	107 **Bh** Bohrium (272)	108 **Hs** Hassium (270)	109 **Mt** Meitnerium (276)	110 **Ds** Darmstadtium (281)	111 **Rg** Roentgenium (280)							

Lanthanide Series[1]	58 **Ce** Cerium 140.1	59 **Pr** Praseodymium 140.9	60 **Nd** Neodymium 144.2	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.4	63 **Eu** Europium 152.0	64 **Gd** Gadolinium 157.3	65 **Tb** Terbium 158.9	66 **Dy** Dysprosium 162.5	67 **Ho** Holmium 164.9	68 **Er** Erbium 167.3	69 **Tm** Thulium 168.9	70 **Yb** Ytterbium 173.0	71 **Lu** Lutetium 175.0
Actinide Series[2]	90 **Th** Thorium 232.0	91 **Pa** Protactinium 231.0	92 **U** Uranium 238.0	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

You may refer to the following table, which shows the relative activities of a number of metals, when answering questions that involve metals:

Metal Activity

K	*most reactive*
Ca	
Na	
Mg	
Al	
Zn	
Fe	
Cu	*least reactive*

You may refer to the following table, which shows SI prefixes, their symbols, and their values, when answering questions that involve the conversion of units:

SI Prefix	Symbol	Value
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

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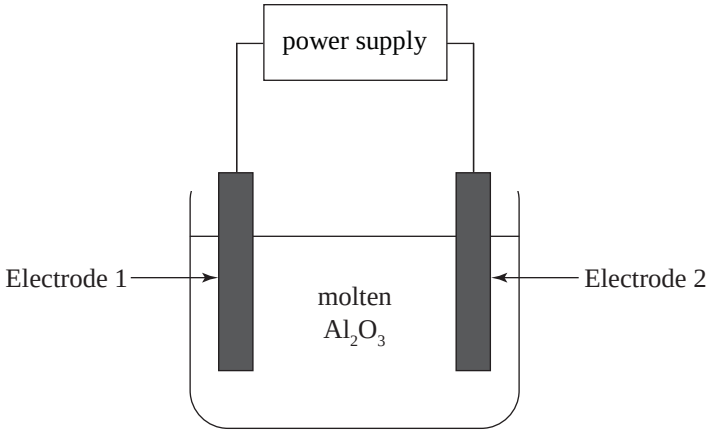
QUESTION 1

Different methods are used in the production of metals from their minerals.

(a) In the production of aluminium an electrochemical cell is used to convert Al_2O_3 into Al, as shown in the diagram below:



(i) (1) State the energy conversion that occurs in this type of electrochemical cell.

_____ (2 marks)

(2) Aluminium is produced at Electrode 1.

(A) Write a half-equation for the reaction at Electrode 1.

(2 marks)

(B) State whether Electrode 1 is positive or negative.

_____ (1 mark)

(3) Explain why an aqueous solution of an aluminium compound cannot be used in this method of production.

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_____ (2 marks)

(ii) Aluminium can be used to produce hydrogen. Under appropriate conditions, aluminium will react vigorously with water to form hydrogen gas and aluminium oxide.

(1) Write an equation for this reaction.

(2 marks)

(2) Hydrogen can be produced more economically by other methods.

Suggest why it is costly to use aluminium to produce hydrogen.

_____

_____ (1 mark)

(b) In the production of copper large amounts of SO_2 are produced when a sulfide mineral is roasted at high temperatures.

(i) The release of SO_2 into the atmosphere may lead to the formation of acid rain.

Describe, with the aid of two equations, how the release of SO_2 into the atmosphere lowers the pH of rainwater.

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_____ (4 marks)

(ii) State one other environmental problem associated with the use of high temperatures in this method of production.

_____

_____ (1 mark)

(c) Copper can be produced by heating its oxide with carbon.

Explain why a similar method cannot be used to produce aluminium.

_____

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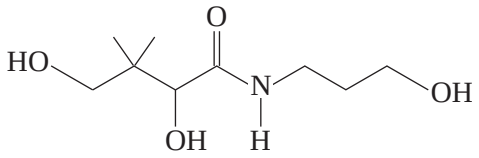
_____ (2 marks)

TOTAL: 17 marks

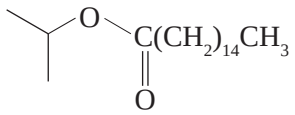
QUESTION 2

The manufacture of cosmetics involves the use of a wide variety of compounds.

(a) The structural formulae of two compounds, **A** and **B**, used in hairstyling products are shown below:



Compound A



Compound B

(i) Explain which compound, **A** or **B**, would be easier to wash out of hair with water alone.

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_____ (3 marks)

(ii) A condensation reaction can be used to produce Compound **A**.

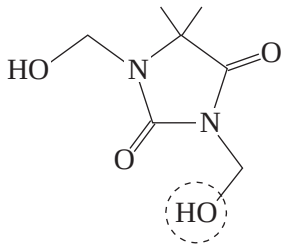
(1) Name the functional group in Compound **A** that forms in the condensation reaction.

_____ (1 mark)

(2) Draw the structural formula of one reactant that can be used to produce Compound **A** by condensation.

(2 marks)

(b) Compound **C**, a preservative used in shampoos, has the structural formula shown below:



Compound C

(i) One hydroxyl group is circled on the structural formula above.
Classify this group as primary, secondary, or tertiary.

_____ (1 mark)

(ii) Write the molecular formula of Compound **C**.

_____ (2 marks)

(iii) Compound **C** acts as a preservative by the slow release of HCHO.

(1) State the systematic name of HCHO.

_____ (2 marks)

(2) HCHO reacts with Tollens' reagent.

(A) State the observation expected as a result of this reaction.

_____ (1 mark)

(B) Draw the structural formula of the organic product of this reaction.

(2 marks)

(c) Talc is a silicate mineral added to face powders to give a smooth texture. The formula of talc is $Mg_3(Si_2O_5)_2(OH)_2$.

(i) State the charge on the silicate ion in talc.

_____ (1 mark)

(ii) Name the shape of the structural unit on which silicate ions are based.

_____ (1 mark)

TOTAL: 16 marks

QUESTION 3

Methanol, CH_3OH, is an excellent fuel that can be produced by a number of methods.

(a) The enthalpy of combustion of CH_3OH may be determined by calorimetry.

(i) Write an equation for the complete combustion of CH_3OH.

(2 marks)

(ii) In a laboratory experiment a spirit burner containing CH_3OH was used to heat 150 mL of water in a metal calorimeter. The results obtained are shown below:

Mass of CH_3OH burnt	= 0.34 g
Initial temperature of water	= 18°C
Final temperature of water	= 25°C

4.2 J of heat energy is needed to raise the temperature of 1.0 g of water by 1.0°C.

(1) Calculate the heat energy, in kilojoules, absorbed by the water.

(2 marks)

(2) Hence calculate the molar enthalpy of combustion of CH_3OH.

(3 marks)

(b) CH_3OH can be produced industrially by the reaction of CO and H_2 with a suitable catalyst at high pressures. The equation for this reaction is shown below:

$$CO_{(g)} + 2H_{2(g)} \rightleftharpoons CH_3OH_{(g)}$$

(i) Write an expression for the equilibrium constant, K_c, for this reaction.

(2 marks)

(ii) The composition of one mixture of these three gases at 150°C is shown below:

Gas	**Concentration (mol L^{-1})**
CO	0.10
H_2	0.20
CH_3OH	0.0014

At 150°C $K_c = 2.2$.

(1) Use the information above to show that the system is not at equilibrium.

(2 marks)

(2) Hence state, with a reason, whether the concentration of CO will increase or decrease as the system shifts to reach equilibrium.

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_____ (2 marks)

(c) CH_3OH can also be produced at room temperature and room pressure from the oxidation of CH_4 by certain bacteria in aqueous conditions. The equation for the overall reaction is shown below:

$$2CH_4 + O_2 \longrightarrow 2CH_3OH$$

(i) Write a half-equation for the conversion of CH_4 into CH_3OH.

(2 marks)

(ii) State, with a reason, one advantage of producing CH_3OH by this method rather than by the industrial method described in part (b).

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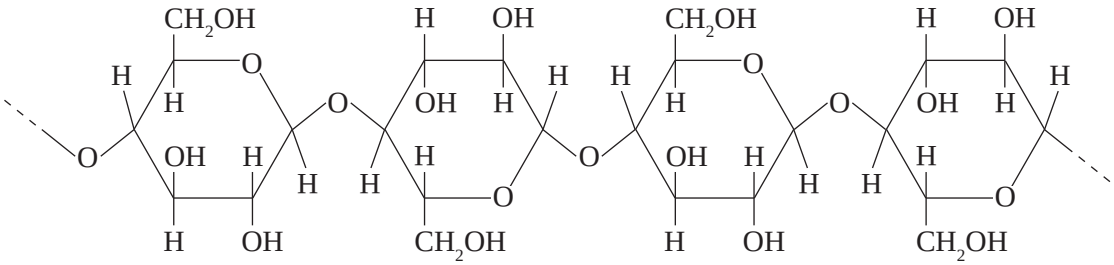
_____ (2 marks)

TOTAL: 17 marks

QUESTION 4

Supermarkets in South Australia no longer supply free lightweight polyethene carry bags because of environmental concerns. Alternative carry bags include those made from natural fibres such as cotton.

(a) Cotton is composed of the carbohydrate cellulose. The structural formula of a section of cellulose is shown below:



(i) State one reason why cellulose is insoluble in water.

_____

_____ (1 mark)

(ii) In nature, cellulose can be hydrolysed to form glucose.

Write an equation for this hydrolysis.

(2 marks)

(iii) Explain why cellulose is classified as a carbohydrate.

_____

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_____ (2 marks)

(iv) Cotton is often bleached to improve its appearance. A solution of NaClO may be used in the bleaching process. In this solution ClO^- is in equilibrium with HClO, as shown in the equation below:

$$ClO^- + H_2O \rightleftharpoons HClO + OH^-$$

The proportions of HClO and ClO^- in the solution can be controlled by the addition of HCl.

Explain the effect that the addition of HCl would have on the value of $\frac{[HClO]}{[ClO^-]}$.

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_____ (3 marks)

Credit will be given for answers to part (b) which show clear, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer should be confined to the space provided and should take approximately 10 minutes.

(b) There are advantages associated with the production and use of carry bags made from natural fibres rather than from polyethene.

Describe and explain two of these advantages.

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_____ (8 marks)

TOTAL: 16 marks

You may write on this page if you need more space to finish your answers to Question Booklet 1. Make sure to label each answer carefully (e.g. 1(b)(i) continued).

Government of South Australia

SACE Board of SA

External Examination 2009

2009 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

2

15 pages, 4 questions

Wednesday 11 November: 1.30 p.m.

Question Booklet 2

Write your answers to Questions 5 to 8 in this question booklet.

QUESTION 5

Various sprays, gels, and bandages are used in the treatment of athletes' injuries.

(a) Minor sprains are often treated with cold sprays. Methylpropane is a solvent commonly used in cold sprays.

(i) Draw the structural formula of methylpropane.

(2 marks)

(ii) When sprayed onto the skin, methylpropane produces a cooling effect because of its low boiling-point.

Explain why methylpropane has a low boiling-point.

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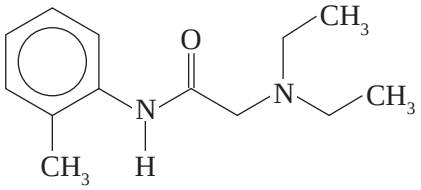
_____ (3 marks)

(b) Some sprays contain local anaesthetics such as lignocaine. The structural formula of lignocaine is shown below:



(i) (1) On the structural formula above, circle the amino group. (1 mark)

(2) Classify the amino group as primary, secondary, or tertiary.

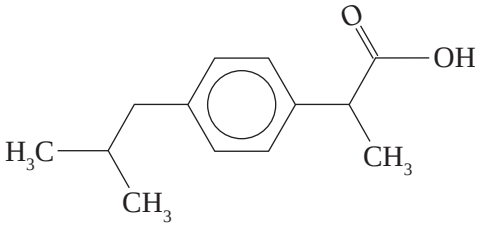
_____ (1 mark)

(ii) Lignocaine is effective as an anaesthetic only when the amino group is protonated.

Draw the structural formula of lignocaine, showing the amino group in its protonated form.

(2 marks)

(c) More serious sprains are treated with ibuprofen, an anti-inflammatory drug. The structural formula of ibuprofen is shown below:



(i) Explain why ibuprofen has only limited solubility in water.

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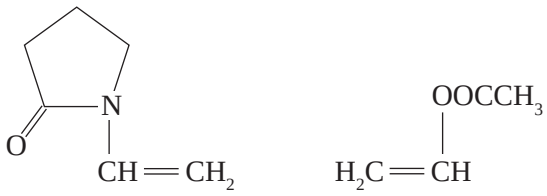
_____ (3 marks)

(ii) Ibuprofen gel is applied to the skin. The usual concentration of ibuprofen in this form is 50 mg g^{-1} of gel.

Calculate the percentage, by mass, of ibuprofen in the gel.

(2 marks)

(d) Spray-on bandages contain a polymer formed from two different monomers. The structural formulae of the two monomers used are shown below:



The repeating unit of the polymer is formed from one molecule of each monomer.

Draw the structural formula of the repeating unit.

(2 marks)

TOTAL: 16 marks

QUESTION 6

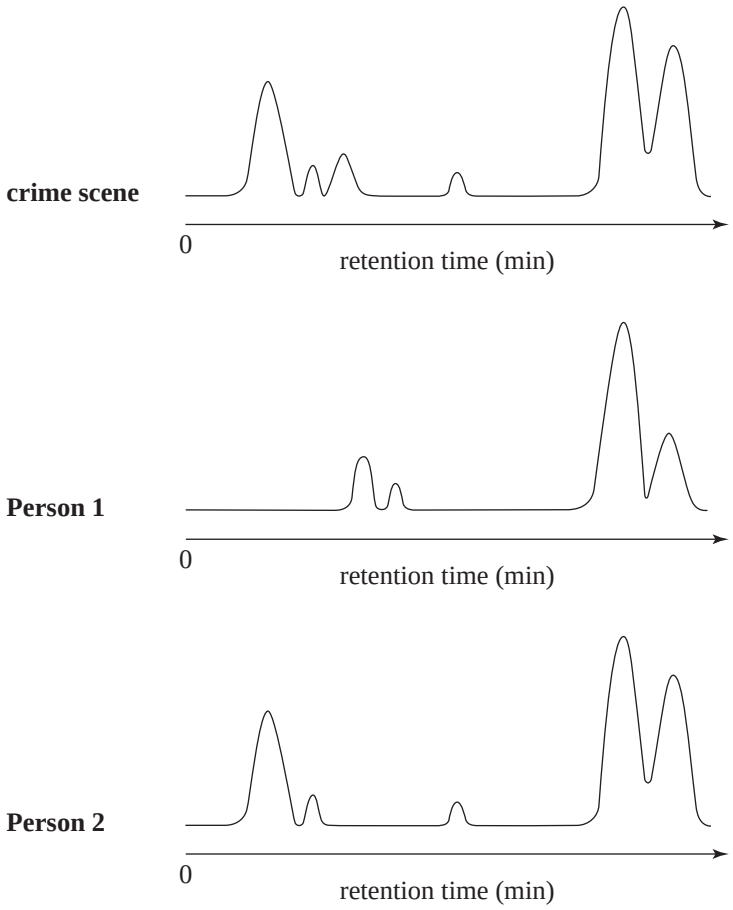
The analysis of compounds in soil can be used to provide forensic evidence. Samples of soil from a crime scene and from the shoes of two people suspected of having been at the crime scene were analysed.

(a) One sample of soil contained a high concentration of H_2S.

State whether this sample of soil was more likely to have come from an aerobic environment or an anaerobic environment.

_____ (1 mark)

(b) Decaying plant matter adds a variety of long-chain carbon compounds to the soil. Chromatography was used to analyse the three samples of soil for long-chain carbon compounds. The chromatograms obtained are shown below:



(i) Explain how the chromatograms above indicate that Person 2 is more likely than Person 1 to have been at the crime scene.

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_____

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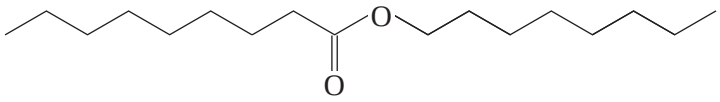
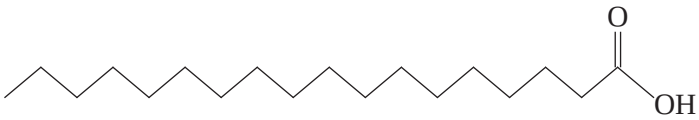
_____ (2 marks)

(ii) Long-chain carbon compounds **D**, **E**, and **F** were all found in the sample of soil from the crime scene. The structural formulae of these compounds are shown below:



Compound D

Compound E



Compound F

(1) Identify which one of the compounds above is a product of the hydrolysis of a triglyceride.

_____ (1 mark)

(2) Describe how a solution of bromine could be used to distinguish Compound **E** from Compound **F**.

_____

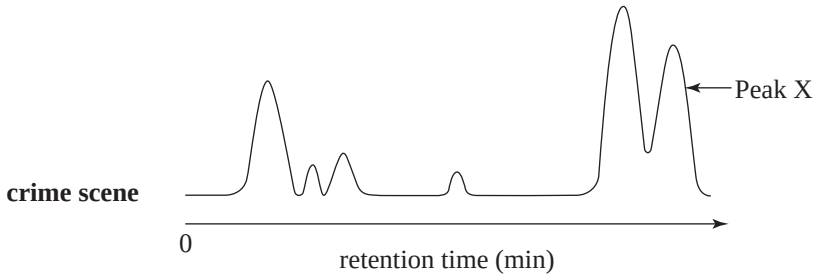
_____

_____

_____ (2 marks)

(3) The chromatograms were obtained using a polar stationary phase.

State whether Peak X on the chromatogram below is most likely to be due to Compound **D**, Compound **E**, or Compound **F**. Explain your answer.



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_____ (4 marks)

(c) The sample of soil from the crime scene contained calcium ions. An aqueous solution was prepared from the sample and the concentration of calcium ions was determined by atomic spectroscopy.

(i) The solution emitted light when sprayed into a flame.

(1) One calcium ion in the solution had an electron configuration of $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ 4s^1$.

Explain why this calcium ion emitted light.

_____

_____

_____

_____ (2 marks)

(2) Using subshell notation, write the electron configuration of the calcium ion after it had emitted light.

_____ (1 mark)

(ii) A 0.5 g sample of the soil was used to prepare a 10.0 mL solution. The concentration of calcium ions in the solution was found to be 15 mg L^{-1}.

Calculate the concentration, in ppm, of calcium in the soil.

(3 marks)

TOTAL: 16 marks

QUESTION 7

The concentration of greenhouse gases in the Earth's atmosphere is increasing.

(a) Explain how an increase in the concentration of greenhouse gases may lead to an increase in the average temperature of the Earth's atmosphere.

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_____ (3 marks)

(b) NF_3 is a potent greenhouse gas. The amount of NF_3 in the atmosphere is increasing as a result of its increasing use in the electronics industry.

(i) Draw a diagram to show the bonding and shape of a molecule of NF_3.

(2 marks)

(ii) State the oxidation number of N in the NF_3 molecule.

_____ (2 marks)

(iii) Explain the sign and magnitude of the oxidation number of N in the NF_3 molecule.

_____

_____

_____

_____ (2 marks)

(c) Farming practices are responsible for the emission of large amounts of greenhouse gases such as CO_2 and CH_4 into the atmosphere. Various methods can be used to reduce these greenhouse gas emissions.

(i) CO_2 emissions can be reduced by growing animal feed on the farm.

(1) Growing animal feed involves the process of photosynthesis.

Write an equation for the process of photosynthesis.

(2 marks)

(2) Explain one way in which CO_2 emissions can be reduced by growing animal feed on the farm instead of transporting it from other places.

_____

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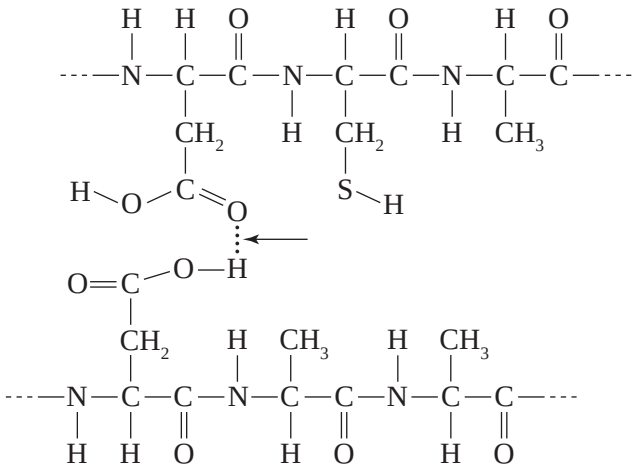
_____ (2 marks)

(ii) CH_4 emissions from cows can be reduced by modifying a protein in cows.

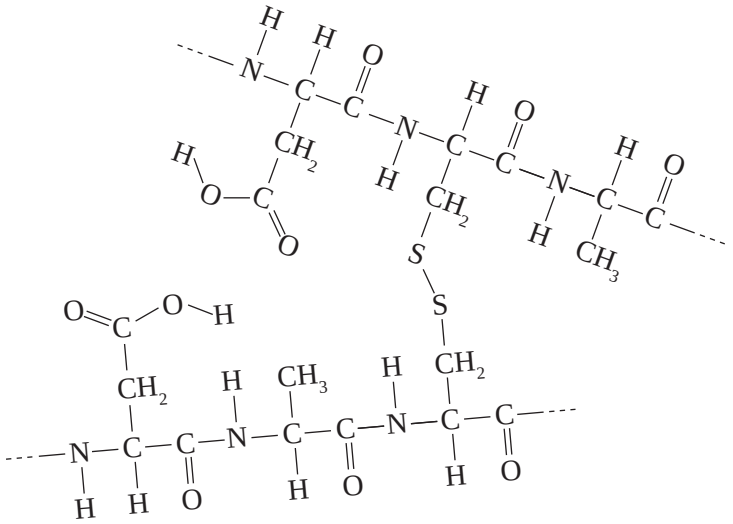
(1) Sections of adjacent protein chains in one unmodified protein are shown in the diagram below:



State the type of interaction between the protein chains that is indicated by the arrow on the diagram above.

_____ (1 mark)

(2) The same sections of adjacent protein chains in one modified protein are shown in the diagram below:



(A) Describe how the interaction between the protein chains would be substantially different in the modified protein.

_____

_____

_____

_____ (2 marks)

(B) State why the biological function of the protein would change as a result of this modification.

_____ (1 mark)

TOTAL: 17 marks

QUESTION 8

Phosgene, $COCl_2$, is a colourless, poisonous gas used in the production of insecticides and plastics.

(a) Draw a diagram to show the bonding and shape of a molecule of $COCl_2$.

(2 marks)

(b) Phosgene is produced from the reaction of the gases CO and Cl_2, as shown in the equation below:

$$CO + Cl_2 \rightleftharpoons COCl_2$$

The energy released during this reaction is 220 kJ mol^{-1}.

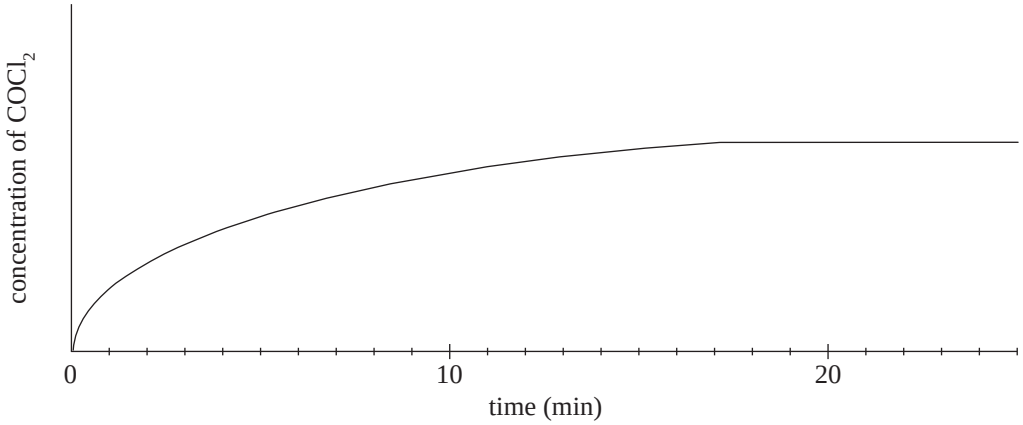
(i) (1) Write a thermochemical equation for the formation of $COCl_2$.

(2 marks)

(2) Calculate the number of kilojoules of energy released in the production of 1000 kg of $COCl_2$.

(3 marks)

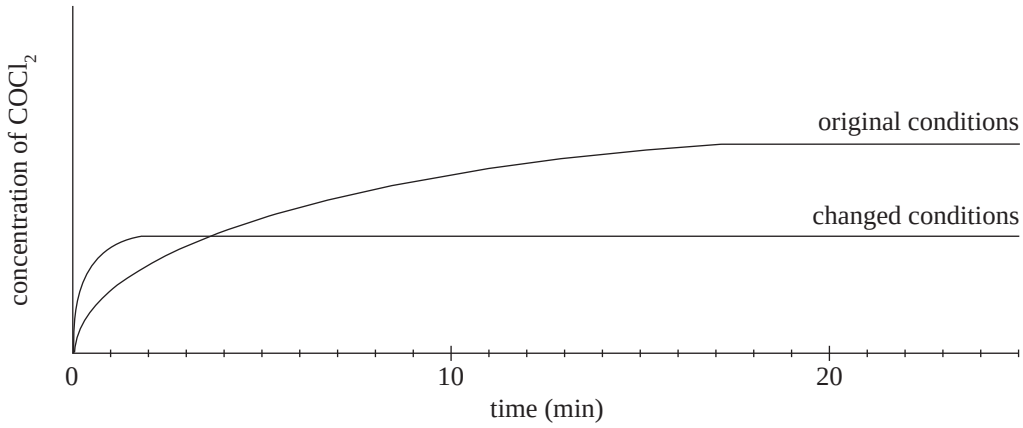
(ii) The diagram below shows the change in concentration of $COCl_2$ in a reaction mixture over a 25-minute period:



(1) State the time at which equilibrium was reached.

_____ (1 mark)

(2) One change was made to the reaction conditions. The effect of this change is shown in the diagram below:



Identify the change that was made to the reaction conditions.

_____ (1 mark)

Credit will be given for answers to part (iii) which show clear, well-expressed ideas, and which present accurate and relevant information in a well-organised, logical manner.

Your answer should be confined to the space provided and should take approximately 10 minutes.

(iii) In the industrial production of $COCl_2$ it is desirable to select conditions that will give a cost-effective yield in a short time.

Using the equation below for the production of $COCl_2$, explain the effect that an increase in the overall pressure of the gaseous reaction mixture would have on the rate, yield, and cost of the production process.

$$CO + Cl_2 \rightleftharpoons COCl_2$$

(8 marks)

TOTAL: 17 marks

You may write on this page if you need more space to finish your answers to Question Booklet 2. Make sure to label each answer carefully (e.g. 6(b)(ii)(3) continued).

Government of South Australia

SACE Board of SA

External Examination 2009

2009 CHEMISTRY

SACE REGISTRATION NUMBER

SEQ | FIGURES | CHECK LETTER | BIN

CHEMISTRY

QUESTION BOOKLET

3

11 pages, 4 questions

Wednesday 11 November: 1.30 p.m.

Question Booklet 3

Write your answers to Questions 9 to 12 in this question booklet.

QUESTION 9

Acidic soils are causing serious environmental problems in many coastal and rural areas.
When waterlogged soils rich in FeS_2 are exposed to air they become acidic as a result of the formation of H_2SO_4.

(a) H_2SO_4 mobilises Al^{3+} and Mg^{2+} from clays into the soil water and into waterways.

(i) Explain how H_2SO_4 mobilises Al^{3+} and Mg^{2+} from clays into the soil water.

_____

_____

_____

_____ (2 marks)

(ii) In addition to their many uses in nature, waterways are a potential source of water for domestic use.

State one reason why it is undesirable for Al^{3+} and Mg^{2+} to be mobilised from clays into waterways.

Al^{3+}: _____

_____

Mg^{2+}: _____

_____ (2 marks)

(b) In one procedure for predicting potential acidity, FeS_2 in the soil was oxidised by H_2O_2 to form H_2SO_4.

A sample of soil containing FeS_2 was dried, ground finely, and shaken with 50 mL of H_2O_2 solution. An equation for the reaction that occurred is shown below:

$$FeS_2 + \tfrac{15}{2}H_2O_2 \longrightarrow Fe(OH)_3 + 4H_2O + 4H^+ + 2SO_4^{2-}$$

(i) Suggest one reason why the sample of soil was ground finely.

_____ (1 mark)

(ii) The pH of the reaction solution was measured at regular intervals while the mixture was shaken.

(1) State how these pH measurements could have been used to indicate that the reaction was complete.

_____

_____ (1 mark)

(2) The final pH of the reaction solution was 1.5.

Calculate the concentration, in mol L^{-1}, of H^+ in the reaction solution.

(2 marks)

(iii) Explain one advantage of repeating this procedure on several samples of the same soil.

_____

_____

_____

_____ (2 marks)

(iv) One practical problem associated with this procedure is the decomposition of H_2O_2 during storage. Substantial decomposition leads to a different final pH of the reaction solution.

(1) State whether this final pH would be higher or lower than the value measured using fresh H_2O_2.

_____ (1 mark)

(2) State whether the decomposition of H_2O_2 is a source of random error or systematic error.

_____ (1 mark)

(c) Certain oxides can be used to reduce soil acidity.

Explain, in terms of the relative electronegativities of Ca and Si, why CaO will reduce soil acidity but SiO_2 will not.

_____

_____

_____

_____

_____

_____

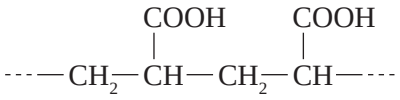
_____

_____ (4 marks)

TOTAL: 16 marks

QUESTION 10

Water-absorbent polymers are used to retain moisture in a variety of applications. The structural formula of a section of one molecule of a water-absorbent polymer is shown below:



(a) State the type of polymerisation reaction by which this polymer was formed.

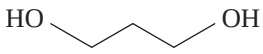
_____ (1 mark)

(b) Draw the structural formula of the monomer used to produce this polymer.

(2 marks)

(c) This polymer is often reacted with other substances to modify its properties for different applications.

(i) For one application the polymer is reacted with small amounts of Compound **X**. The structural formula of Compound **X** is shown below:



Compound X

(1) Write the systematic name of Compound **X**.

_____ (2 marks)

(2) The resultant polymer is more rigid than the original polymer.

Explain how the reaction of the original polymer with Compound **X** produces a polymer of greater rigidity.

_____

_____

_____

_____

_____

_____ (3 marks)

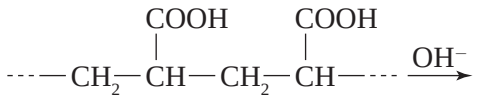
(3) Identify a reactant that could be used, and state the observation that would indicate that the product contains unreacted Compound **X**.

Reactant: _____

Observation: _____

_____ (3 marks)

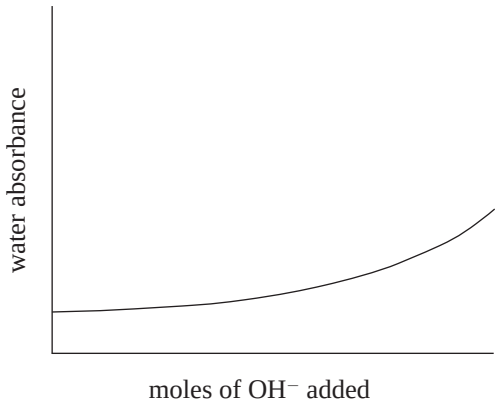
(ii) For another application the original polymer is reacted with hydroxide ions. A section of the original polymer chain is shown below:



original polymer **product**

(1) In the space above, draw the structural formula of one possible polymer product formed in the reaction of this section with OH^-. (2 marks)

(2) Explain the effect that the number of moles of OH^- added has on the water absorbance of the polymer, as shown in the graph below:



_____

_____

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_____

_____ (3 marks)

TOTAL: 16 marks

QUESTION 11

The first stage in the production of zinc from ZnS is the roasting of ZnS in air. This process releases SO_2, which may leak into the surrounding air.

(a) Write an equation for the roasting of ZnS in air to produce SO_2.

(2 marks)

Credit will be given for the correct use of significant figures in answers to part (b). (1 mark)

(b) The following procedure was used to determine the concentration of SO_2 in one sample of polluted air:

Step 1 1.0×10^5 L of the polluted air was bubbled through 0.100 L of 0.02997 mol L^{-1} $KMnO_4$ solution. An equation for the reaction that occurred is shown below:

$$5SO_2 + 2MnO_4^- + 2H_2O \longrightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$$

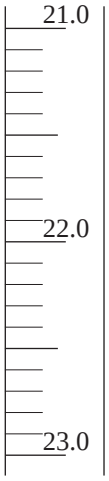
Excess MnO_4^- remained in the solution after the reaction.

Step 2 The excess MnO_4^- was titrated with 0.400 mol L^{-1} Fe^{2+} solution. An equation for the reaction that occurred is shown below:

$$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

A titre value of 22.35 mL was obtained.

(i) On the following diagram, which shows a section of a burette, draw the surface of a solution that would give a reading of 22.35.



(2 marks)

(ii) (1) Calculate the number of moles of MnO_4^- present before the reaction with SO_2 in Step 1.

(2 marks)

(2) State why this result should be reported to three significant figures.

_____

_____ (1 mark)

(iii) Calculate the number of moles of Fe^{2+} required to react with the MnO_4^- in Step 2.

(2 marks)

(iv) Hence calculate the number of moles of MnO_4^- left unreacted after Step 1.

(2 marks)

(v) Hence calculate the number of moles of MnO_4^- that reacted with SO_2 in Step 1.

(2 marks)

(vi) Calculate the number of moles of SO_2 in the 1.0×10^5 L of polluted air.

(2 marks)

(vii) Calculate the concentration, in $\mu g\ L^{-1}$, of SO_2 in the 1.0×10^5 L of polluted air.

(2 marks)

TOTAL: 18 marks

QUESTION 12

The flavour and texture of ice cream are controlled by the use of additives.

(a) A range of compounds may be used to produce flavourings for ice cream. The table below gives information about some of these compounds:

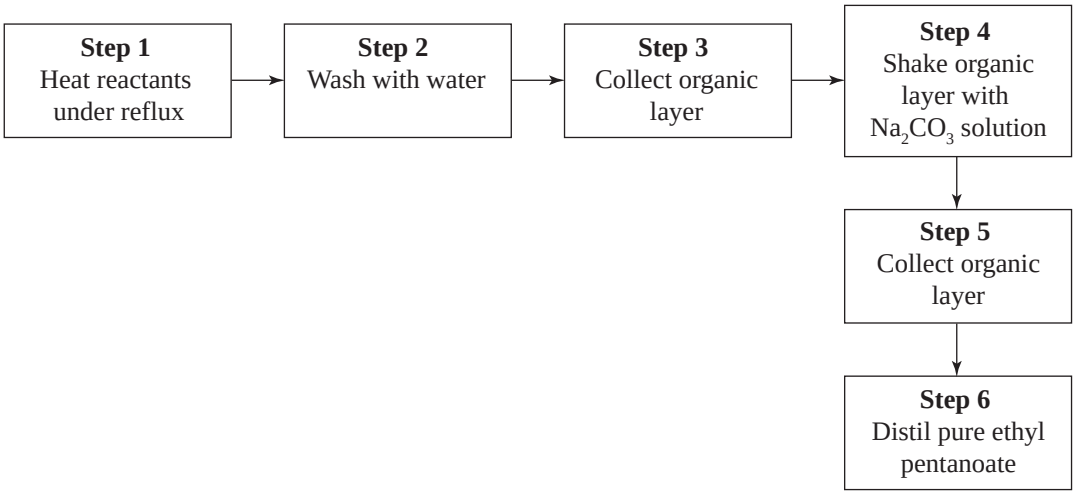
Compound	Solubility in Water
CH_3COOH	soluble
CH_3CH_2OH	soluble
$CH_3CH_2CH_2CH_2COOH$	slightly soluble
$CH_3CH_2CH_2CH_2CH_2OH$	insoluble

Ethyl pentanoate is used as a flavouring in ice cream.

(i) Write an equation for the formation of ethyl pentanoate, choosing appropriate reactants from the table above.

(2 marks)

(ii) The flow chart below shows steps in a laboratory preparation of ethyl pentanoate:



(1) In Step 1 the mixture is heated to increase the rate of the reaction.

Explain the benefit of heating under reflux conditions.

_____

_____

_____

_____ (2 marks)

(2) The addition of a trace of concentrated H_2SO_4 to the reaction mixture in Step 1 increases the rate of the reaction.

Explain the function of the concentrated H_2SO_4.

_____

_____

_____

_____

_____

_____ (3 marks)

(3) Explain why prolonged heating in Step 1 does not lead to an increase in the yield of ethyl pentanoate.

_____

_____

_____

_____ (2 marks)

(4) Identify the two major components in the organic layer after the reaction mixture has been washed with water in Step 2.

_____

_____ (2 marks)

(5) Describe how Step 4 results in an increase in the purity of the ethyl pentanoate product.

_____

_____

_____

_____ (2 marks)

(6) Explain how Step 6 results in an increase in the purity of the ethyl pentanoate product.

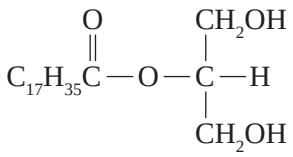
_____

_____

_____

_____ (2 marks)

(b) The creamy texture of ice cream depends on keeping triglycerides dispersed through the frozen aqueous mixture. The compound GMS is one additive used for this purpose. The structural formula of GMS is shown below:



Explain how the GMS molecules help to keep triglycerides dispersed through the frozen aqueous mixture.

_____

_____

_____

_____

_____

_____ (3 marks)

TOTAL: 18 marks

You may write on this page if you need more space to finish your answers to Question Booklet 3. Make sure to label each answer carefully (e.g. 12(a)(ii)(2) continued).